भारतीय मानक
Indian Standard

IS 11189 : 2020

नलकूप के विकास की पद्धति

(पहला पुनरीक्षण)

Methods of Tubewell Development

(First Revision)

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Diamond Core and Waterwell Drilling Sectional Committee, MED 21

FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Diamond Core and Waterwell Drilling Sectional Committee had been approved by the Mechanical Engineering Division Council.

This standard was first published in 1985. In this revision, following modifications are made:

a) Purpose of tubewell development has been defined;
b) Process of tubewell development is added;
c) Chemical method of development is added; and
d) Acceptable sand content for various application is defined.

The Composition of the Committee responsible for the formulation of this standard is given in Annex A.

In reporting the result of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'.

Indian Standard

METHODS OF TUBEWELL DEVELOPMENT

(First Revision)

1 SCOPE

This standard lays down methods and guidelines for development of tubewells.

2 DEFINTIONS

For the purpose of this standard, the following definitions shall apply:

2.1 Aquifer — A geologic formation, groups of formations, or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to wells and springs.

2.2 Draw-Down — It is the distance by which the water level in a well is lowered from static level when pumped at a constant rate of flow.

2.3 Permeability — Permeability or hydraulic conductivity of a medium is indicative of the ease with which water can flow through it. It depends on the properties of the medium affecting flow including porosity, packing, shape, and grain size distribution.

2.3.1 The co-efficient of permeability is the velocity of flow through a permeable material at hydraulic gradient unity.

2.4 Ratio of Submergence — This is the ratio between the lengths of the air line under water to the total length of air line.

2.5 Well Development — It is a treatment of a well to establish the maximum rate of usable water yield without sand content (beyond permissible limit).

3 PURPOSE OF DEVELOPMENT

The primary purpose of well development is to obtain maximum production efficiency from the well. Incidental benefits are stabilization of the structure, minimization of sand pumping and improvement of corrosion and encrustation conditions. The process of careful development results in more efficient well, longer well life and reduced maintenance and operation costs.

4 NEED FOR DEVELOPMENT

All drilling methods cause compaction of materials in the annulus around the hole in variable thickness. In addition fines are driven into the formation, drilling mud invasion takes place forming a mud cake in the wall of the hole. Proper well development breaks down the compacted borehole wall and removes all these added material as well as finer particles of aquifer material. Accordingly the development should be started as soon as possible after filter packing and initial washing of the tubewell. It must not be started later than a fortnight.

5 PROCESS OF DEVELOPMENT

5.1 Development work is started slowly and gently and is then done vigorously as the well develops. Except use of chemicals all the development methods require application of sufficient energy to agitate the natural formation and/or the filter pack and make all the fines to be drawn into the well. It is accomplished by surging of water into and out of the well screen and surrounding material filter pack or formation.

5.2 The development process should start from the bottom most screen and continued upwards to the top most screen.

6 METHODS OF DEVELOPMENT

Numerous methods of well development are available and the same are listed below:

a) Compressed air;
b) Over pumping;
c) High velocity jetting;
d) Surge block plunger;
e) Explosives; and
f) Chemicals.

6.1 Compressed Air Method

There are two methods of development using compressed air, namely open well and back washing.

6.1.1 *Open Well Method*

The arrangement at well head for development by this method is given in Fig. 1. This method of development is a combination of surging and pumping.

Lower the drop pipe 600 mm above the bottom of the deepest screen and place the air line inside the drop pipe at about 300 mm below the bottom of the drop pipe. The compressed air is then turned into the air line to come out and make the water to flow to the screen giving a surging action in the filter pack and formation

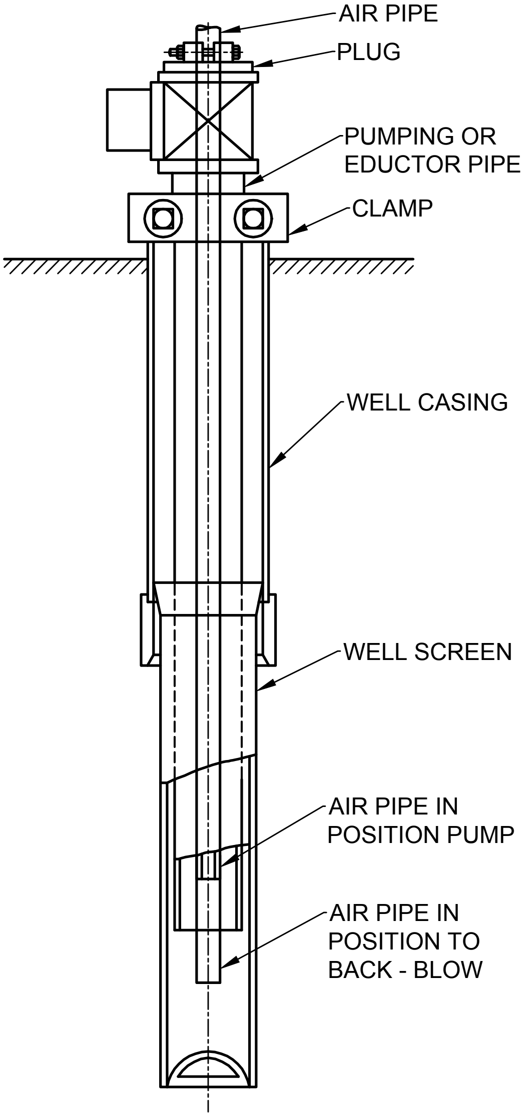


FIG. 1 ARRANGEMENT FOR OPEN WELL DEVELOPMENT WITH COMPRESSED AIR

around it. The pipe is then pulled back into the drop pipe and the water is pumped out reversing the flow of water from the formation and filter pack back into the well through the screen. The well is then continued to pump till water is nearly sand free. The process is repeated number of times till water is nearly clear. The drop pipe is then placed one by one for all screens and the same process is repeated at the end the drop pipe is placed inside housing pipe or 10 m above the topmost screen and pumped with air method till water is nearly clear of sand and silt.

Currently the compressed air development is done directly in the well instead of using drop pipe. In this method it is advisable to start development of well with lowest screen first (if the well is with multiple screens). The air line should be placed a meter above the top of the lowest most screen. The valve on tank is then opened allowing the air in the tank to rush into the well. There will be brief but forceful surge of water down wards which will force the water into the screen agitating the gravel and formation particles. Immediately after words the pumping operation starts reversing the flow of water through the screen and bring with it the finer particles from the gravel and the formation. Pumping by air shall be continued till water clears up significantly and then the same process shall be repeated till water for most part of pumping is nearly sand free. This process shall be repeated at every screen length. After this the well shall be pumped with the air line placed in housing pipe or about 10 m above the top most screen. After this the air line may be lowered to the bottom of the well to clean the filling, if any.

The pressure needs of compressor and the volume of air required for this process are given below.

Minimum pressure required kg /cm = (length of air line non pumping water level)/ 10.019 (All lengths in meter)

This equation gives the minimum air pressure to lift the water for starting submergence. A safety factor of 25 percent is needed to be added to this value for good performance. Based on this equation, the recommended air pressure for different depths of wells to develop the deepest screen with minimum 60 percent submergence of air line are given in Table 1.

Application of too much air in the well can result in collapse of screen especially when screen is choked. To overcome this situation the use of drop pipe is recommended. To minimize the initial pumping rate the air line should be placed at shallow submergence even with large air capacity compressor. However, if drop is not used, introduction of small air at greater submergence will produce low yields to minimize chances of screen collapse.

To obtain a discharge rate of 1 000 lpm, the air capacity of the compressor shall be 7.08 m^3/min (250 CFM) at good submergence and about 60 m lift. The

Table 1 Air Compression Capacity (Kg/cm square /PSI) *Versus* Bore Well

(*Clause* 6.1.1)

Sl. No.	Depth of Well (m)	Water Level (m)	Length of Air Line (m)	Length of Air Line Below Water Level (m)	Required Air Pressure kg/ cm	Required Air Pressure with 25 % added kg/cm	Calculated Air Pressure PSI	Recommended Capacity of air Compressor kg/cm /(PSI)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
i)	100	10	90	80	7.98	9.98	141.9	10/150
ii)	150	15	140	125	12.48	15.59	221.7	15/250
iii)	150	20	140	120	11.97	14.96	212.7	15/250
iv)	200	20	190	170	16.96	21.12	301.5	20/300
v)	200	30	190	160	15.96	19.95	283.7	20/300
vi)	200	40	190	150	14.97	18.71	266.7	20/300
vii)	250	20	240	220	21.96	27.45	390.3	30/400
viii)	250	30	240	210	20.96	26.2	372.6	30/400
ix)	250	40	240	200	19.96	24.97	354.8	30/400
x)	250	50	240	190	18.96	23.7	337.0	25/350
xi)	250	60	240	180	17.96	22.47	319.2	25/350
xii)	300	30	290	260	25.95	32.44	461.3	35/500
xiii)	300	40	290	250	24.96	31.20	443.6	35/500
xiv)	300	50	290	240	23.96	29.95	425.9	30/450
xv)	300	60	290	230	22.96	28.70	408.0	30/450
xvi)	300	70	290	220	21.96	27.45	390.3	30/400
xvii)	300	80	290	210	20.96	26.20	372.6	30/400
xviii)	300	90	290	200	19.96	24.95	354.8	30/400
xiv)	350	30	340	310	30.94	38.67	549.9	40/550
xv)	350	40	340	300	29.94	27.42	532.1	40/550
xvi)	350	50	340	290	28.94	36.17	514.3	40/550
xvii)	350	60	340	280	27.95	34.93	496.7	35/500
xviii)	350	70	340	270	26.95	33.69	479.1	35/500
xix)	350	80	340	260	25.95	32.44	461.3	35/500
xx)	350	90	340	250	24.96	31.20	443.6	35/500
xxi)	400	60	390	330	32.94	41.17	585.4	45/600
xxii)	400	70	390	320	31.94	39.92	567.7	45/600
xxiii)	400	80	390	310	30.94	38.67	549.9	40/550
xxiv)	400	90	390	300	29.94	27.42	532.1	40/550

air requirement goes on increasing if submergence decreases and lift increases.

The recommended size of drop pipe and air line for different rate of discharges are given in Table 2.

For larger well casing the educator pipe is recommended.

Table 2 Recommended Size of Drop Pipe and Air Line

(*Clause* 6.1.1)

Sl. No.	Pumping Rate (liters/min)	Well Casing Diameter if no Educator Pipe is Used (mm)	Drop Pipe Diameter or Casing if no Educator Pipe is Used (mm)	Air Line Diameter (mm)
(1)	(2)	(3)	(4)	(5)
i)	300-450	100	76	25
ii)	450-550	127	89	25
iii)	550-800	152	100	32
iv)	800-1 350	152	127	38
v)	1 350-2 200	203	152	51

6.1.2 *Closed Head or Back Washing*

The top of the housing pipe is closed air tight and the drop pipe and air line are lowered as in open head method. One more short length air line is lowered through the top plate. The two air lines are connected with three way valve. The arrangement for closed head method is shown in Fig. 2. The diameter of the air line is 2-6 cm and of drop pipe 150-200 mm for 300 mm diameter housing pipe.

Initially the well is pumped using drop pipe and air line as done in open well method. In this period the air is shut off from entering short length air line. When the water is clear enough the air is cut off by closing the three way valve and in the well is allowed to recoup. The three way valve is then turned to allow the air to pass through the short length air line. The built up of pressure of this air forces the water level to drop and the water from the well is forced out of the screen into the gravel pack and formation disturbing the grains there. When the water is lowered to the bottom of the drop pipe, it will not go further down as the air would escape through the drop pipe giving a whistling sound. The pressure gauge would also show no further built up of pressure. At this stage the air supply is cut off

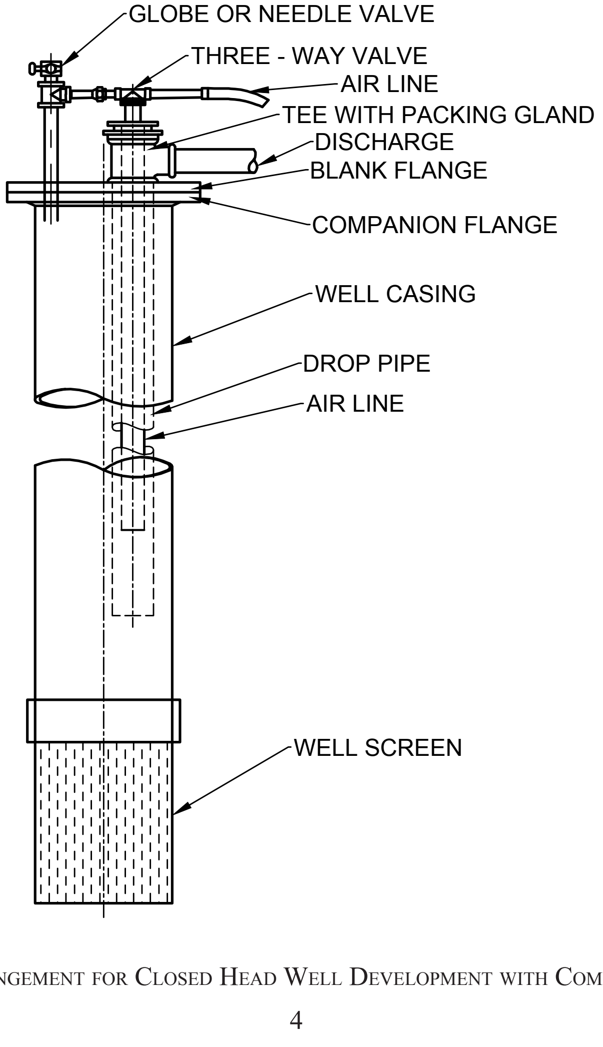


FIG. 2 ARRANGEMENT FOR CLOSED HEAD WELL DEVELOPMENT WITH COMPRESSED AIR

and the air cock is opened to release the pressure inside well casing. This would make the reversal of water flow from the aquifer into the well through the screen and bring back with it the finer particles from the aquifer. Simultaneously, the pumping operation is started as done earlier to remove all the finers from the well with the pumped water. This process is repeated till discharged water is fairly clear.

6.2 Over Pumping

6.2.1 *Continuous Over Pumping*

As the title suggests the well is pumped at a rate higher than the desired yield from the well. For this the capacity of the pump should be a minimum of 1.25 times higher than the desired yield. This method in itself does not give satisfactory results and hence, is not recommended. This method should be combined with more effective development methods and should be done at the end of final development process before pumping test.

6.2.2 *Bach Washing/Raw Hiding (Pumping and Surging)*

The arrangement for raw hiding is similar to that of over pumping. The pump should be minimum of 1.25 the desired yield from the well. The pump installed should be without check or foot valve fitted. The pumping and surging is achieved by alternatively lifting a column of water to a significant distance above the pumping water level and then letting the water fall back into the well. In this operation the discharge is increased in steps of ½, ¾ and full capacity of the pump or 1.25 times the desired yield. In this procedure the pump is started and as soon as the water appears in the discharge mouth, the pump is shut off, the water in the pump column pipe then falls back into the well and surges out of the screen. The pump is started again as soon as the power unit and starting unit will permit. After 5 such starting and stopping episodes, pump the well till the water is nearly clear. Repeat the process till water discharged at this rate is nearly clear from the beginning. The same process may be repeated at the three rates of discharges till water at the highest rated capacity of the pump is sand free. At each rate of pumping the period of pumping shall not be less than two hours.

6.3 High Velocity Jetting

High velocity jetting is done with either water or air. Figure 3 shows a jetting tool with four nozzles. The nozzle orifice could be 4.8 mm, 6.4 mm, 9.5 mm or 12.7 mm depending on the pressure capacity of the pump. The diameter of the tool should be 25 mm less than the inside diameter of the screen. The other equipment required for this method are high pressure pump, clean water, high pressure hoses and connections along with a rotating and lifting arrangement say a rotary drilling machine. The bottom of the tool could be closed or fitted with check valve. The size of the pipe feeding water to the jets should be 4-7.5 cm in diameter depending on the length of the pipe and the discharge. The approximate velocity generated per nozzle are given in Table 3.

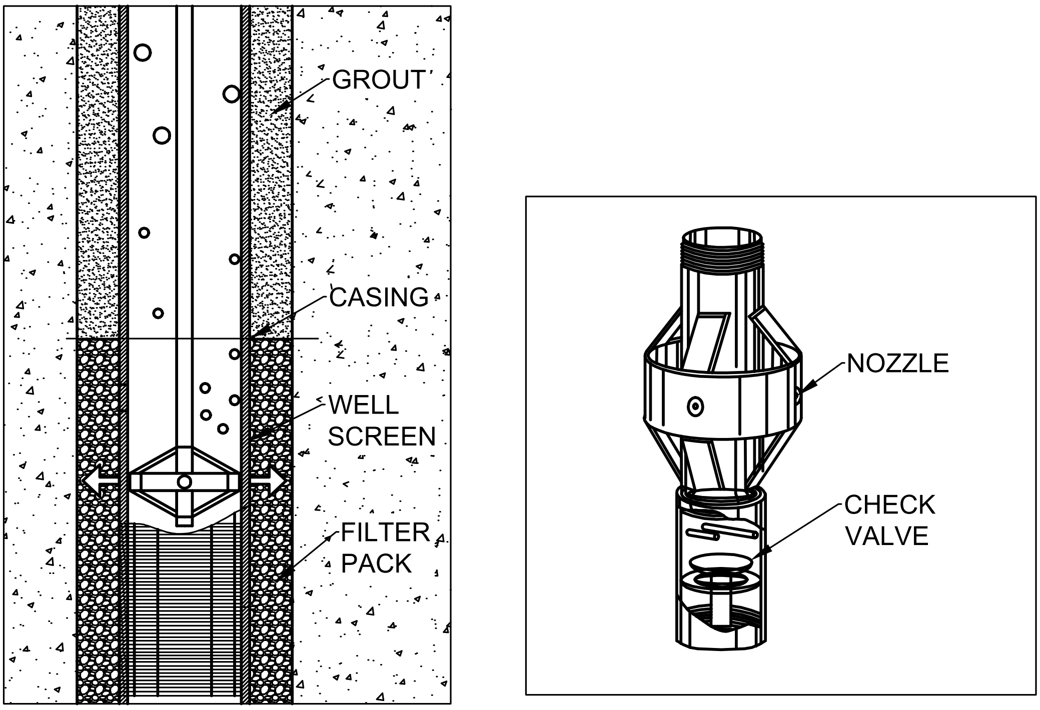


Fig. 3 Four-Nozzel Jetting Tool with and Without Check Valve

Table 3 Approximate Jet Velocity and Discharge per Nozzle

(*Clause* 6.3)

Sl No.	Nozzle Orifice Diameter	Nozzle Pressure 100psi (690 kPa)		Nozzle Pressure 1 150psi (1 030 kPa)		Nozzle Pressure 100psi (1 380 kPa)		Nozzle Pressure 250psi (1 720 kPa)		Nozzle Pressure 300psi (2 070 kPa)	
	mm	Velocity m/sec	Discharge l/m	Velocity m/sec	Discharge l/m	Velocity m/sec	Discharge l/m	Velocity m/sec	Discharge l/m	Velocity m/sec	Discharge l/m
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
i)	4.8	30.5	12	36.6	15	42.7	18	47.3	20	51.8	23
ii)	6.4	30.5	23	36.6	27	42.7	32	47.3	36	51.8	39
iii)	9.5	30.5	51	36.6	62	42.7	73	47.3	80	51.8	88
iv)	12.7	30.5	91	36.6	110	42.7	127	47.3	142	51.8	156

The jetting procedure consists of operating a horizontal water jet inside the well screen in such a way that the high velocity stream of water shoots out through the screen opening. The jetting tool should be rotated slowly and simultaneously raising and lowering it to the entire length of the screen. If this is not done, the screen opening may get damaged by water jet. Jetting with water is almost always done by simultaneous pumping to avoid clogging of the formation.

If water pump is not available jetting with air can be done. The procedure and tools are almost similar to water jetting. Here separate pumping is not required.

6.4 Surge Blocks

Very effective method of development but not much practiced. Solid, vented and spring loaded surge blocks can be used. The solid and vented blocks consists of a body block 2 to 5 cm smaller in diameter then the well screen and fitted with as many as four, 6 to 12 mm thick disks of belting, rubber or other tough material having a diameter the same as the inside diameter of the screen in which they are used. A typical design of solid surge block is given in Fig. 4.

The surge block is attached to the bottom of a drill stem of adequate weight to ensure rapid down or upward stoke. It is best attached to the drill stem of a direct rotary machine. Up and down movement of the block in the screen impart a surging action to the water which is equal in both directions. The down stroke causes sufficient back wash to break up any bridging and the up stroke pulls in the sand grains freed by the surging action. Surging should be started above the screen and continued at the bottom. The surge block should be raised slowly through the screen as surging progresses until all the screen is surged. At the end the well should be bailed to clean the accumulated sediments or the same can be removed using compressed air.

6.5 Explosives

These are sometimes used in hard rock terrain to enlarge crevices and fissures in the borewells drilled in semi or hard formations. Charges of 14 to 230 kg can be used according to the hardness of the rock and the depth at which the charge is to be detonated.

6.6 Chemicals

Numerous chemicals are used to aid in well development. Most common polyphosphates are, sodium tripolyphosphate, sodium pyrophosphate and tetra sodium pyrophosphate. The chemicals act as deflocculants and dispersants of clays and other fine grained materials. Suggested dose of chemicals is suggested as below:

a) For 1 000 liters water in the well a mixture of 20 kg sodium pyrophosphate or tetra sodium pyrophosphate or sodium tripolyphosphate + 5 kg sodium carbonate + 300 ml 5.25 sodium hypochlorite.

b) In addition 1.2 kg of wetting agent pluronic F-68 is added to the mixture for dirt formations.

Polyphosphates should be pre-mixed with hot water before introduction into the well. Efforts should be made to force the solution into the screen at regular interval and after 6-8 h the well should be pumped to waste. Wells in carbonate rocks shall be developed by sulfamic acid or muriatic acid.

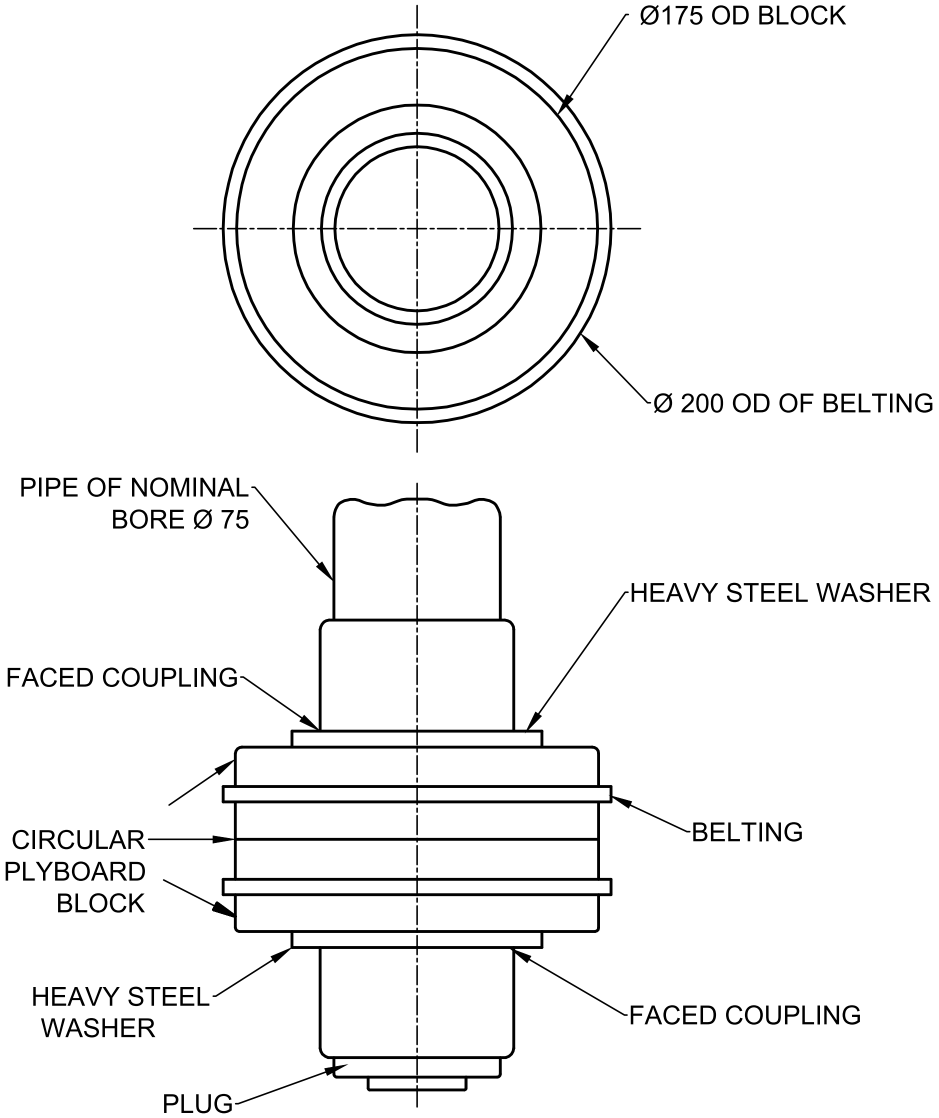
7 ADEQUACY OF DEVELOPMENT

The final development shall be done by over pumping method. It is impractical to assume that even by most powerful development methods the sand content can be totally eliminated. 8 ppm by weight sand content in discharged water can be considered sand free.The degree of development shall be estimated by sand content and colour of water. Accepted sand content for various purposes shall be as under:

Municipal, domestic and industrial supply - 5 ppm by weight

Sprinkler irrigation - 10 ppm by weight

Irrigation - 15 ppm by weight



All dimensions are in millimeter

FIG. 4 TYPICAL DESIGN OF SOLID SURGE BLOCK

ANNEX A

(*Foreword*)

COMMITTEE COMPOSITION

Diamond Core and Water Well Drilling Sectional Committee, MED 21

Organization	*Representative(s)*
Geological Survey of India, Kolkata	Shri Ajay Agarwal (***Chairman***) Shri Anup Kumar Johri (*Alternate*)
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